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## WARTIME REPORT

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MEASUREMENT OF FLYING QUALITIES OF A DOUGLAS A-26B AIRPLANE

(AAF No. 41-39120)

III - STALLING CHARACTERISTICS

By S. A. Sjoberg, H. L. Crane, and H. H. Hoover

Langley Memorial Aeronautical Laboratory  
Langley Field, Va.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Army Air Forces, Air Technical Service Command

MEASUREMENT OF FLYING QUALITIES OF A DOUGLAS A-26B AIRPLANE

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INTRODUCTION

At the request of the Army Air Forces, Air Technical Service Command, flight tests have been made to determine the flying qualities of a Douglas A-26B airplane. The results of the tests made to determine the longitudinal-stability and control characteristics have been reported in reference 1 and the results of the lateral and directional-stability and control tests have been reported in reference 2. This portion of the report presents the results of tests made to determine the stalling characteristics, the variation of maximum normal-force coefficient with flap position, and a calibration of the service airspeed installation.

DESCRIPTION

Figure 1 shows a three-view drawing of the airplane and sections of the wing and tail surfaces. A description of the airplane and several photographs of the airplane are given in reference 1. Figure 2 presents photographs of the wing surface condition and the oil-cooler air intake. Figure 3 is a side-view photograph of the airplane showing the location of the service airspeed head. The airplane was equipped with double-slotted flaps. Figure 4 shows a section of the flap at various deflections.



## INSTRUMENTATION

The instrumentation used in the investigation of stalling characteristics was the same as that used in the longitudinal-stability tests described in reference 1. In the tests made to determine the variation of maximum normal-force coefficient with flap position, an electrical control-position recorder was mounted on the outboard tip of the left flap. The airspeed was measured with a shielded total head and a swiveling static head which was mounted 1 chord length ahead of and slightly below the right-wing tip. The static pressure was corrected for position error for all flap settings both power on and engines idling by means of a trailing static bomb. For one flight tufts were fastened to the upper surface of the wing. The tufts were photographed from an airplane flown in formation with the A-26B airplane as it was stalled.

Correct service indicated airspeed as used in this report is defined by the formula  $V_i = 45.08 f_o \sqrt{q_c}$  where  $V_i$  is in miles per hour,  $f_o$  is the compressibility factor at sea level, and  $q_c$  is the difference between total pressure and static pressure in inches of water corrected for position error.

## STALLING CHARACTERISTICS

### Straight Flight

The straight-flight stalling characteristics were investigated in the rated power-clean, cruising, gliding, approach, landing, wave-off, and take-off conditions. The stalls were made by gradually reducing the airspeed while attempting to hold straight flight. Figures 5 through 8 are time histories of stalls in the rated power-clean, gliding, landing, and wave-off conditions. Figures 9, 10, and 11 are tuft studies showing the stall progression over the wing in the gliding and landing conditions, and in the flaps-up condition with one propeller feathered and the other engine delivering rated power. The reason for including a tuft study with one propeller feathered was to make possible a comparison with wind-tunnel studies of stalling over the lip of the wing duct which were made with propellers removed. Tuft studies were not made with power on, because the A-26B airplane climbed away from the observing airplane in the stall approaches.



The straight-flight stalling characteristics, which satisfied the requirements of reference 3, may be summarized as follows:

1. In all conditions there was adequate stall warning in the form of buffeting and except in the wave-off condition a marked increase in pull force and rearward movement of the control column.
2. The tuft studies (figs. 9, 10 and 11) show that root stall occurred. The root stall decreased the downwash at the tail and thus accounted for the increase in pull forces and up-elevator deflections required at the stall. A premature breakdown of flow over the right-wing duct lips was noted in the gliding condition, but this flow breakdown did not occur with the flaps down and probably would not occur with power on.
3. With engines idling, flaps up or down a pitching oscillation occurred at the stall. Figure 9 shows the stall pattern for the flaps-up, engines idling condition to be symmetrical. Because of the symmetrical stall pattern no abrupt rolling motions occurred. Recovery from the pitching oscillation could be promptly effected by application of down elevator.
4. With power on the airplane rolled, usually to the left, at the stall. The rolling motion could be controlled and recovery could be made by deflecting the elevator downward.

#### Turning Flight

The stalling characteristics in turning flight were investigated in the rated power-clean condition. In these tests the airplane was trimmed at the maximum speed for level flight and constant acceleration turns were made as the airspeed was gradually reduced to the stall warning. Figure 12 is a time history of a typical left turn in which this procedure was followed.

Good stall warning was again present in the form of buffeting, and recovery could be made by moving the elevator down.



VARIATION OF MAXIMUM NORMAL-FORCE COEFFICIENT  
WITH FLAP POSITION

Stalls were made in straight flight both with engines idling and with rated power with various flap settings to determine the variation of maximum normal-force coefficient with flap position. The pilot set the flaps at 0, 1/2, 3/4, 7/8, and full deflection using the cockpit indicator. An electrical control-position recorder attached to the outboard tip of the left flap measured the actual flap angles. The airplane normal-force coefficients were obtained from the formula

$$C_N = \frac{Wn}{5.2 q_c S}$$

where  $W$  is the airplane weight in pounds,  $n$  is the normal acceleration in "g" units,  $S$  is the wing area in square feet, and  $q_c$  is the difference between the measured total and static pressures in inches of water corrected for position error. Account has been taken of the change in weight of the airplane during flight.

The maximum normal-force coefficients were taken before any abrupt pitching or rolling motions occurred. With the power off, the airplane performed a mild pitching oscillation which in some cases tended to increase in amplitude as the stall progressed. The maximum normal-force coefficient was taken early in the oscillation. Occasionally greater normal-force coefficients were obtained as the oscillation increased in amplitude, apparently because of the rapid changes in angle of attack during the oscillation. These values were not maintained long enough to be considered as usable maximum normal-force coefficients.

Table I presents the weights, center-of-gravity positions, and flap and landing-gear positions corresponding to the maximum normal-force coefficients obtained. Figure 13 shows the variation of maximum normal-force coefficient with flap angle with the engines idling and also with rated power.



With engines idling the average values of maximum normal-force coefficient obtained from several stalls were 1.32 with the flaps retracted and 1.94 with the flaps fully extended.

In making any comparison of the maximum normal-force coefficients obtained in flight with maximum lift coefficients obtained in wind tunnels it is necessary to use wind-tunnel values in which the model was trimmed and to make a correction for the difference between lift coefficient and normal-force coefficient.

#### CALIBRATION OF SERVICE AIRSPEED INSTALLATION

On one flight the pilot used a sensitive airspeed meter connected to the service airspeed installation. By comparing the airspeeds recorded on the pilot's notes with those obtained from the NACA recorder, which was connected to the swiveling static head and the shielded total head, a calibration of the service airspeed installation was obtained. Figure 14 is a plot of the error in the service airspeed installation against service indicated airspeed. In the preparation of this figure account has been taken of the scale error of the particular meter used. Corrections were applied to the airspeeds from the NACA recorder for position error and for the effect of compressibility at sea level. Data were used only from runs in which the sideslip angle was less than  $1^\circ$ . The airspeed indicated by the service airspeed installation was approximately 10 miles per hour low at 300 miles per hour and the error increased with speed.

Figure 15 illustrates the large error in indicated airspeed due to sideslip at low speeds. At 140 miles per hour in the landing condition the service airspeed indicator read approximately 25 miles per hour high when the angle of sideslip was  $12^\circ$ . This error would probably be considerably reduced if the pitot-static head were mounted ahead of the wing tip instead of on the vertical tail. The pilot considered the sensitivity of the airspeed system to yaw objectionable especially during landings.

#### CONCLUSIONS

1. The A-26B airplane had good stalling characteristics in all conditions tested in both straight and turning flight. Good stall warning was always present in the form of buffeting and, except in



the wave-off condition, a marked increase in pull force and rearward movement of the control column. Recovery from the stall could always be made by normal use of the controls.

2. The average maximum normal-force coefficients obtained with engines idling were 1.32 with flaps up and 1.94 with flaps full down.

Langley Memorial Aeronautical Laboratory  
National Advisory Committee for Aeronautics  
Langley Field, Va., January 4, 1945

#### REFERENCES

1. Crane, H. L., Sjoberg, S. A., and Hoover, H. H.: Measurement of Flying Qualities of a Douglas A-26B Airplane (AAF No. 41-39120). I - Longitudinal Stability and Control Characteristics. NACA MR No. L4L06, 1944.
2. Sjoberg, S. A., Crane, H. L., and Hoover, H. H.: Measurement of Flying Qualities of a Douglas A-26B Airplane (AAF No. 41-39120). II - Lateral and Directional Stability and Control Characteristics. NACA MR No. L5A04, 1945.
3. Anon.: Stability and Control Requirements for Airplanes. AAF Specification No. C-1815, Aug. 31, 1943.



TABLE I

RATED POWER						
$C_{N_{max}}$	Weight	Center-of-gravity position (percent)	Gear	Flaps	Cowl flaps	Oil-cooler door
1.76	29,800	23	Up	Up	Closed	One-half open
1.77	29,600	32	Up	Up	Closed	One-half open
1.74	29,400	32	Up	Up	Open	Do.
2.32	29,450	30	Down	18.5°	Closed	Do.
2.35	29,300	30	-do-	17°	Open	Do.
2.19	27,500	23.5	-do-	16°	--do--	Do.
2.34	29,250	30	-do-	24.5°	--do--	Do.
2.75	29,150	30	-do-	34°	--do--	Do.
2.79	29,050	30	-do-	43.5°	--do--	Do.
2.98	27,850	25.5	-do-	50°	--do--	Do.
2.84	29,100	21	-do-	50°	--do--	Do.
2.94	28,600	30	-do-	50°	--do--	Do.
3.04	28,950	30	-do-	50°	--do--	Do.
POWER OFF						
1.32	28,100	27.5	Up	Up	Closed	One-half open
1.31	29,500	23	Up	Up	Closed	One-half open
1.36	29,300	32	Up	Up	One-half open	One-half open
1.33	29,800	32	Up	Up	Closed	<sup>1</sup> Do.
1.33	29,450	32	Up	Up	--do--	Do.
1.52	29,350	30	Down	17°	--do--	Do.
1.63	29,200	30	-do-	24.5°	--do--	Do.
1.72	29,100	30	-do-	34°	--do--	Do.
1.86	29,000	30	-do-	43.5°	--do--	Do.
1.99	28,400	30	-do-	50°	--do--	Do.
1.94	29,500	30	-do-	50°	--do--	<sup>1</sup> Do.
1.86	28,950	30	-do-	50°	--do--	Do.

<sup>1</sup>Indicate flight in which wing was covered with tufts.

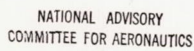
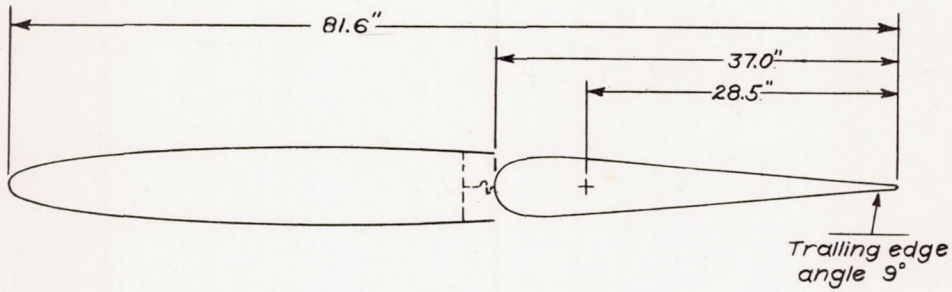
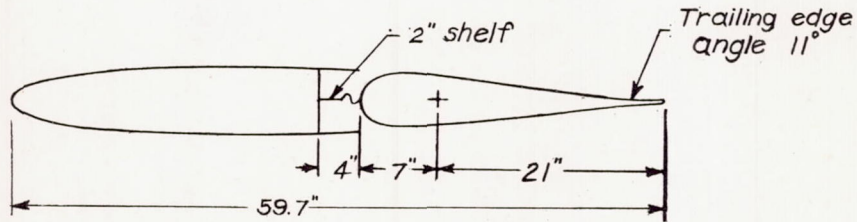


Figure 1.

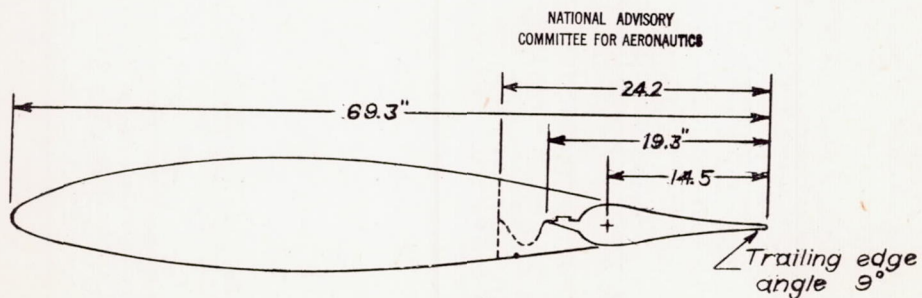




Section vertical tail 49 inches from tip



Section of horizontal tail 76.5 inches from airplane center line



Wing section 352 inches from airplane center line

(b) Sections through vertical tail, horizontal tail, and wing at aileron. Douglas A-26B airplane.

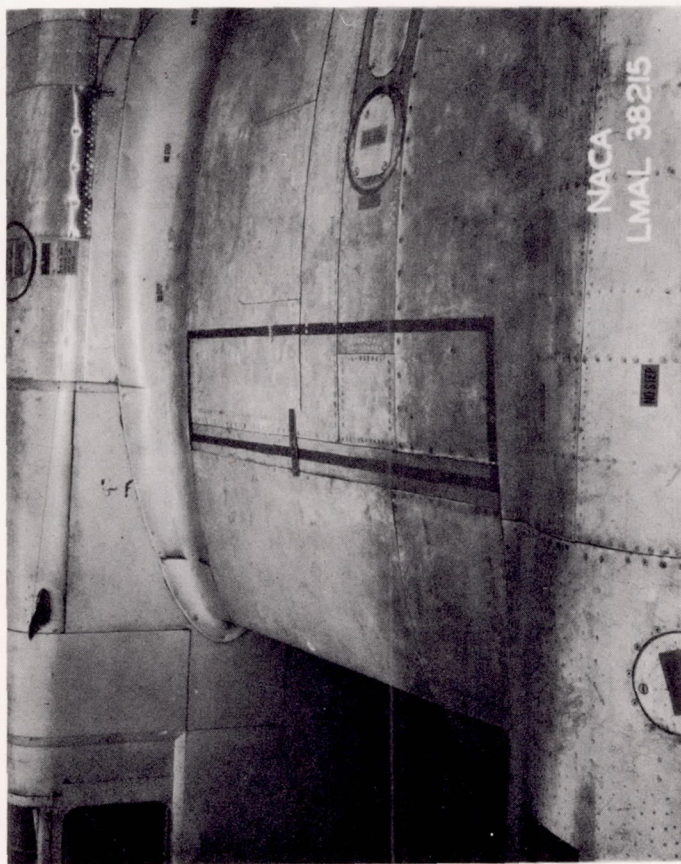
Figure 1.- Concluded.



(a) Leading edge at oil-cooler duct.

Figure 2.- Photographs showing surface condition of Douglas A-26B wing.





(b) Top surface inboard of nacelle.

Figure 2.- Continued.



(c) Leading edge inboard of nacelle.

Figure 2.- Concluded.



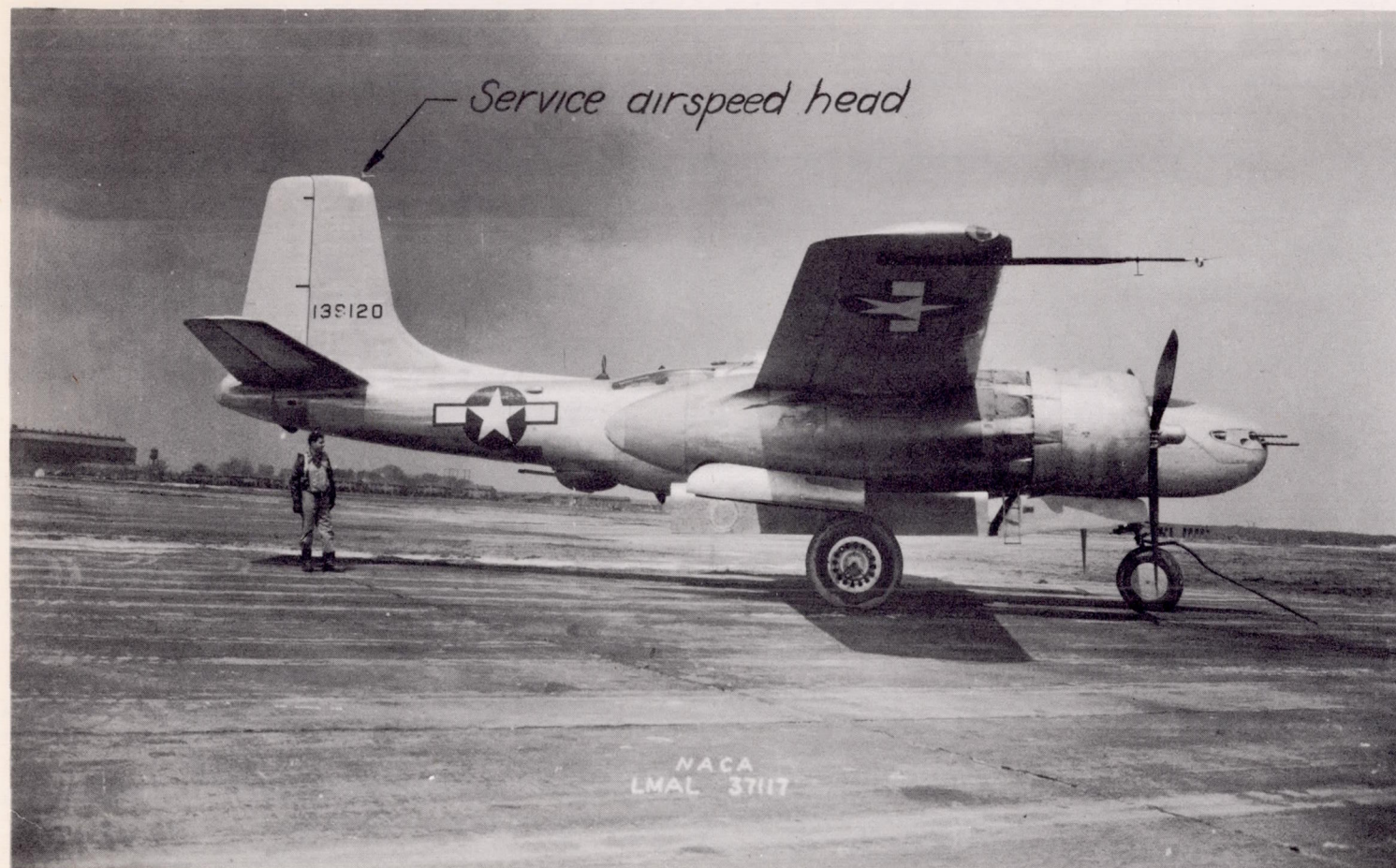


Figure 3.- Side view of Douglas A-26B airplane showing service airspeed head.

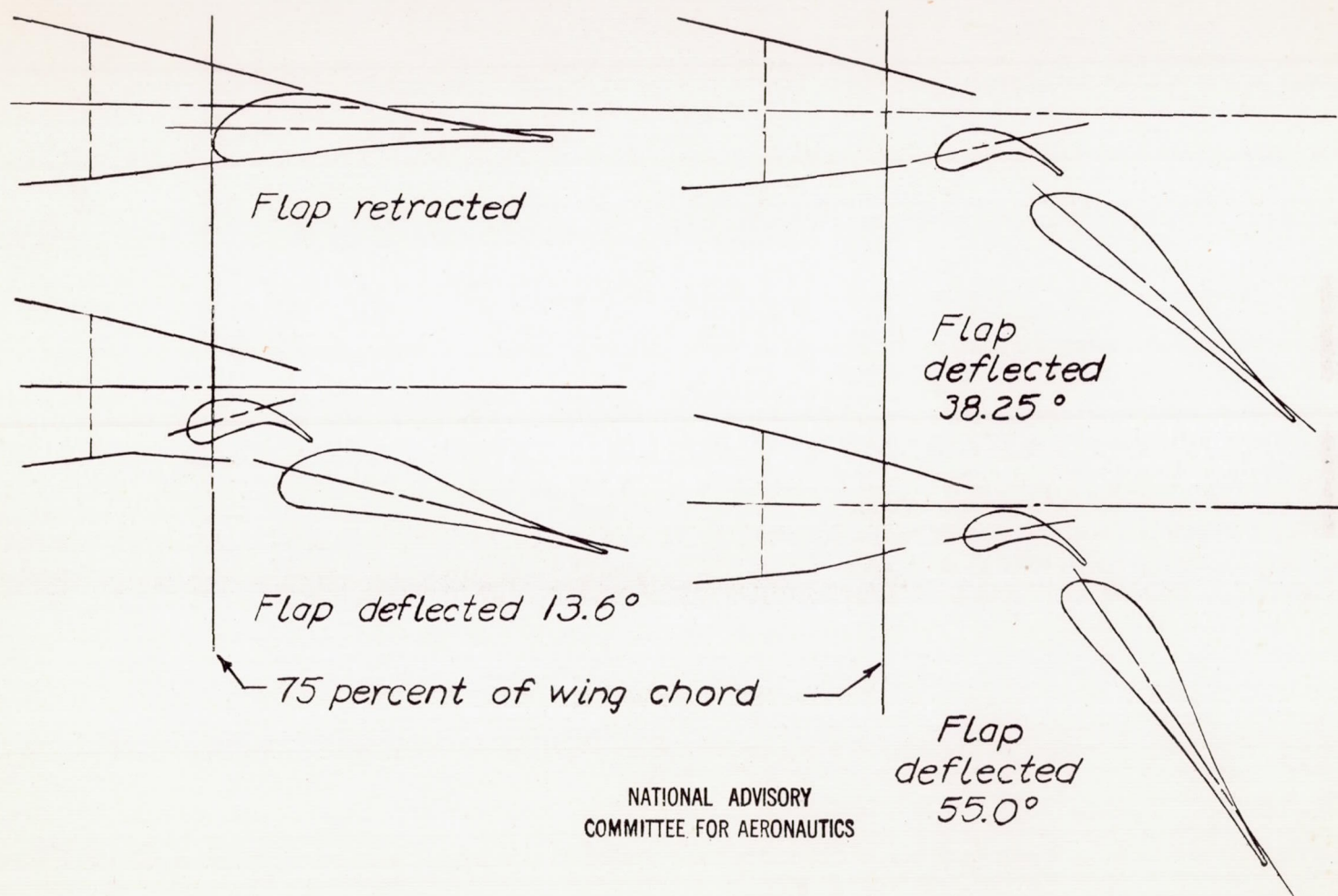


Figure 4.- Section through flap at various deflections.



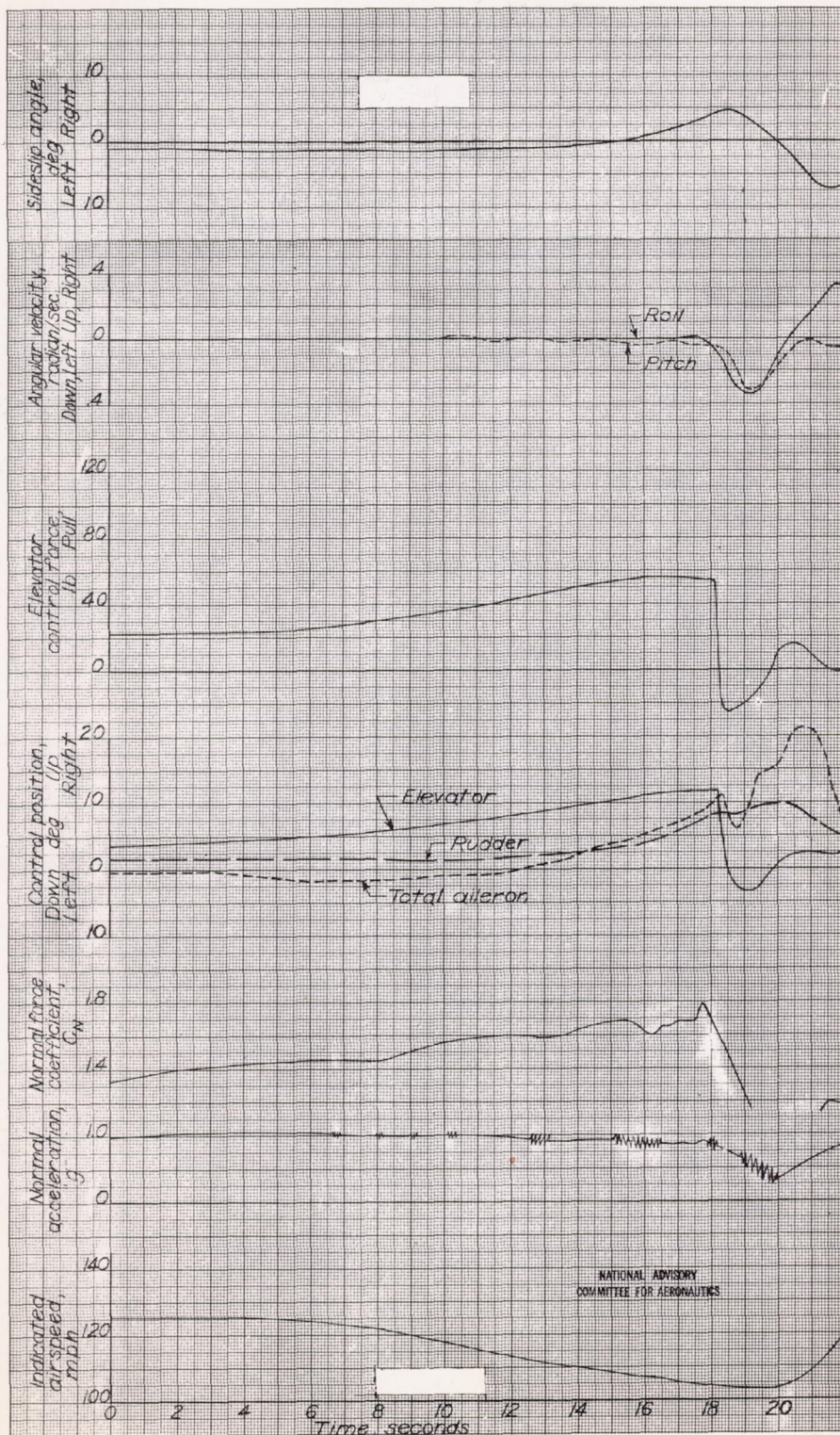


Figure 5.- Time history of a stall in the rated-power clean condition (flaps up, landing gear up, cowl flaps closed, oil cooler one-half open, 41.5 in. Hg. at 2400 rpm, c.g. at 23 percent M.A.C.), Douglas A-26B airplane.



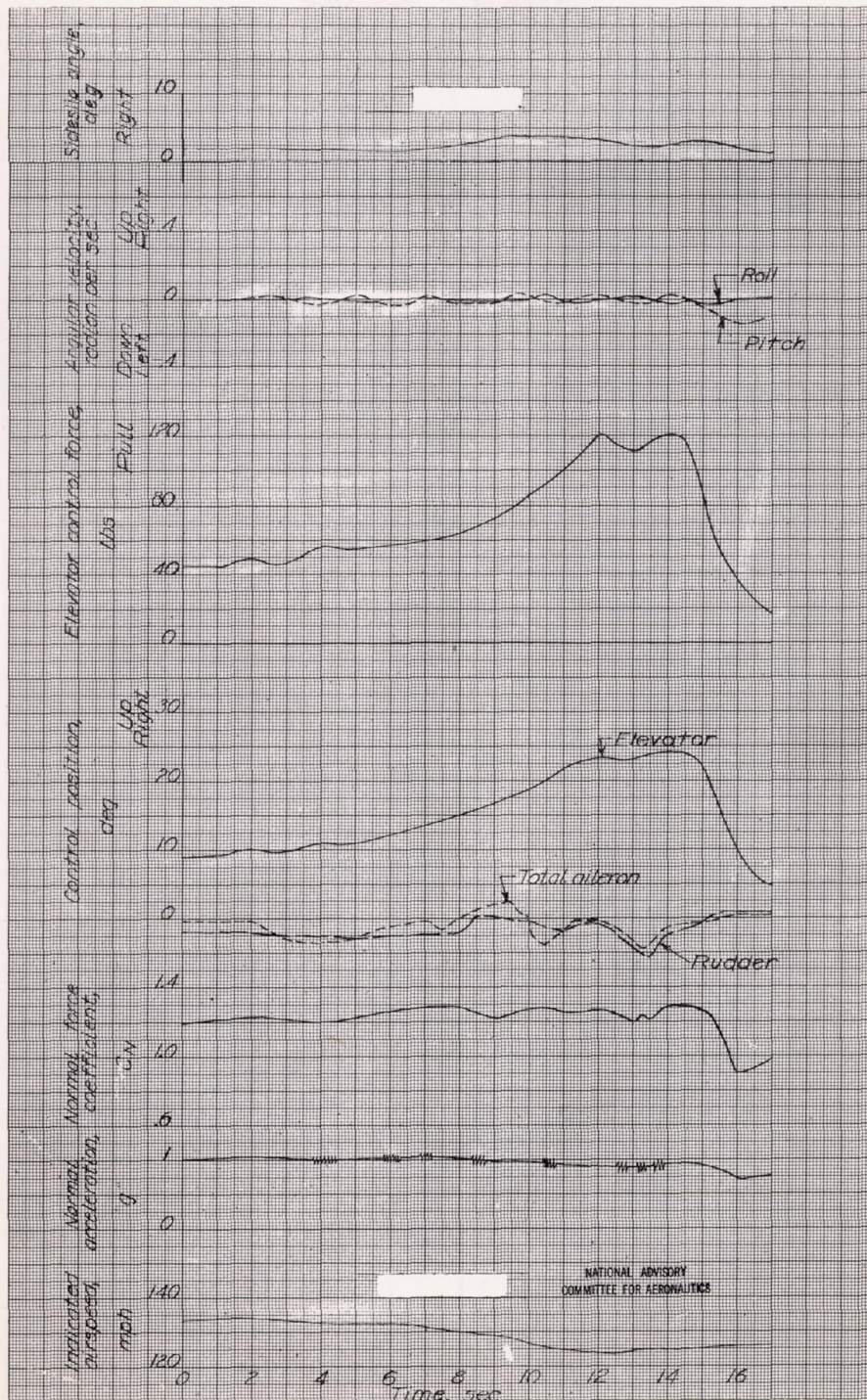


Figure 6.- Time history of a stall in the gliding condition (flaps up, landing gear up, cowl flaps closed, oil cooler one-half open, engines idling, c.g. at 23 percent M.A.C.), Douglas A-26F airplane.



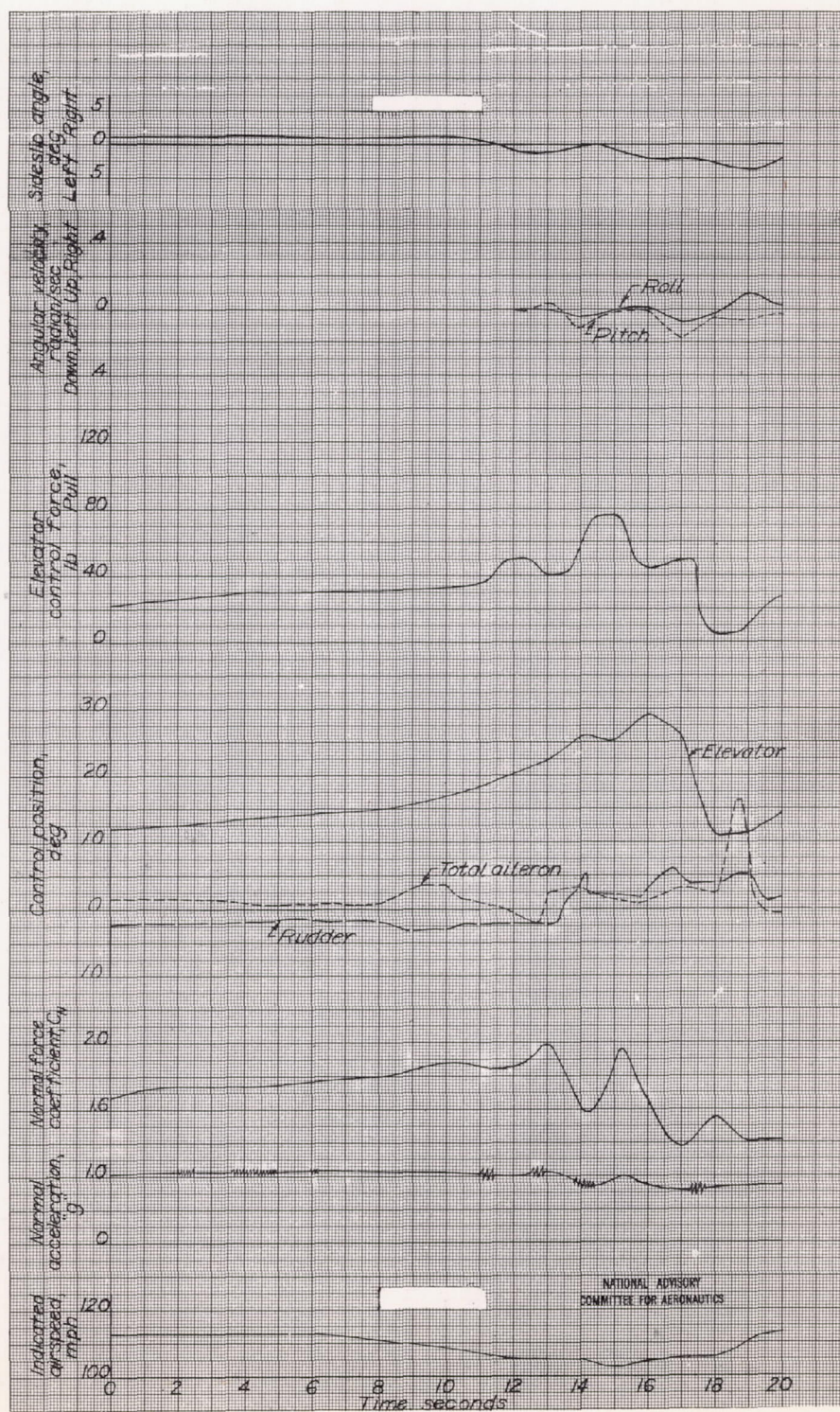


Figure 7.- Time history of a stall in the landing condition (flaps down, landing gear down, cowl flaps open, oil cooler one-half open, engines idling, c.g. at 23 percent M.A.C.), Douglas A-26B airplane.



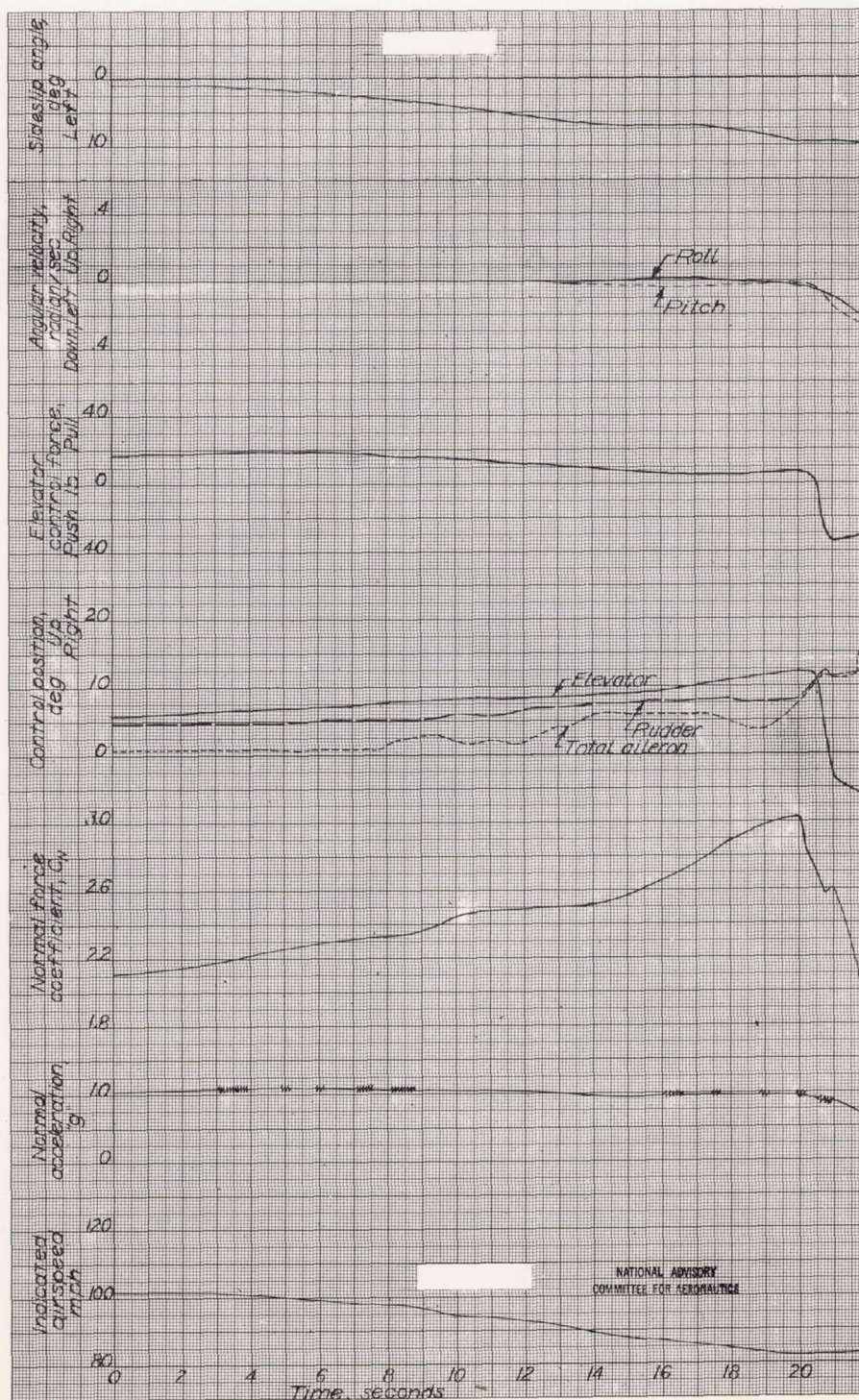


Figure 8.- Time history of a stall in the wave-off condition (41.5 in. Hg. at 2400 rpm, flaps down, landing gear down, cowl flaps open, oil cooler one-half open, c.g. at 23 percent M.A.C.), Douglas A-26B airplane.



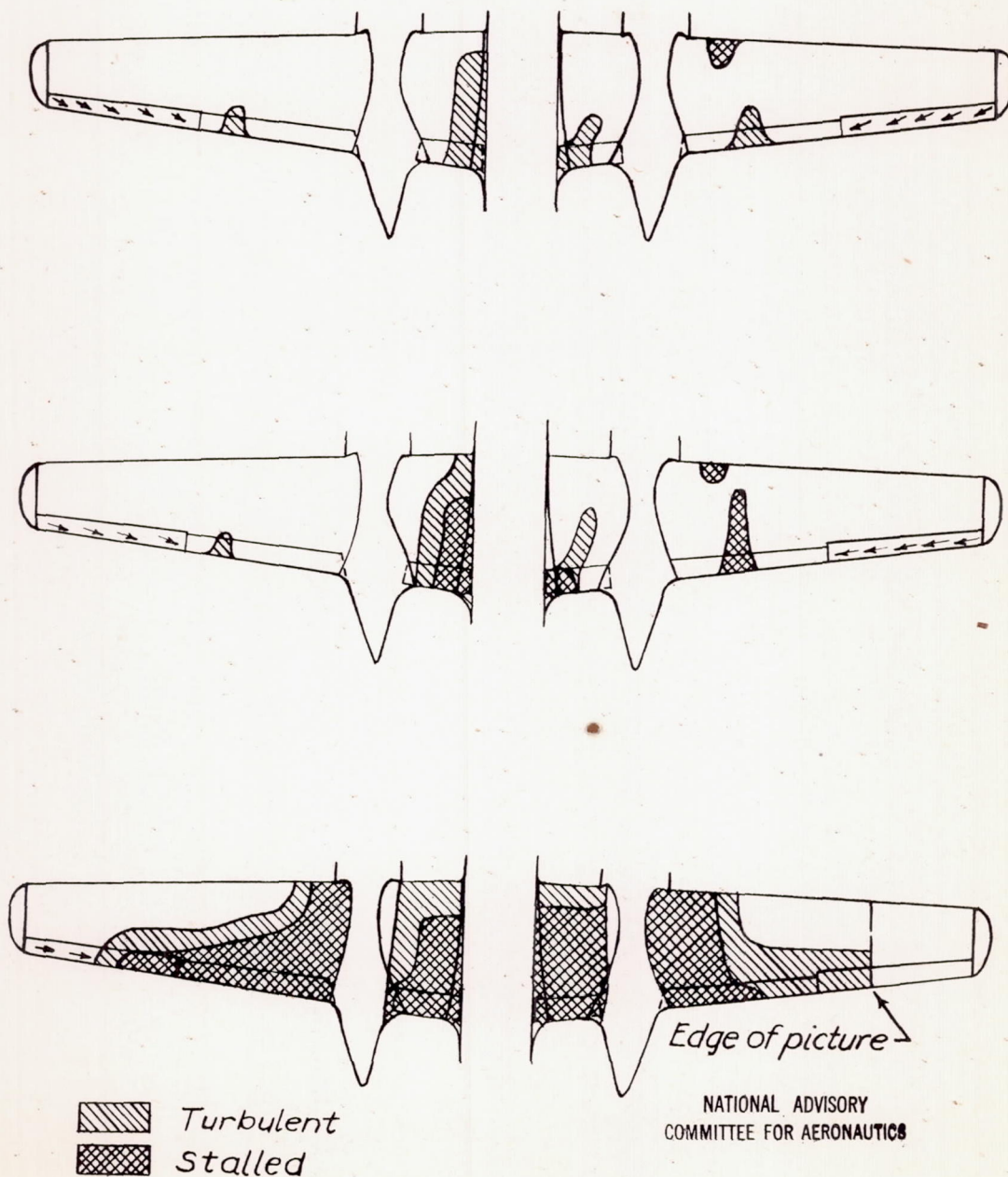
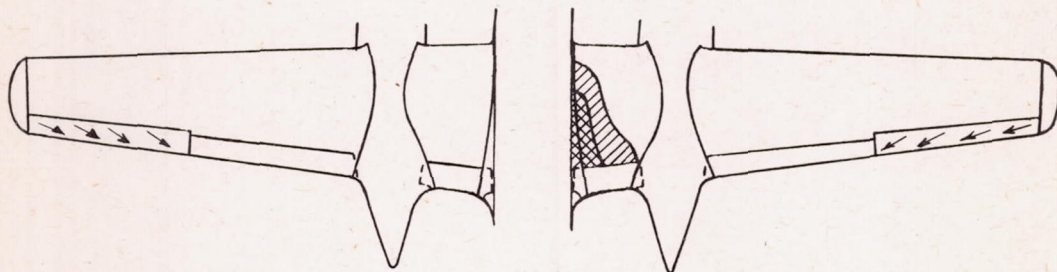
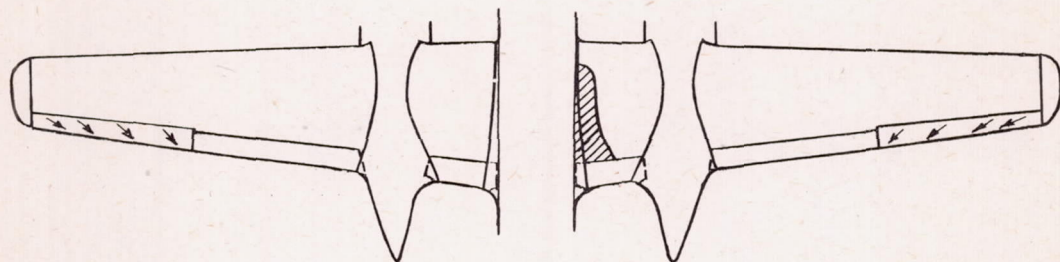
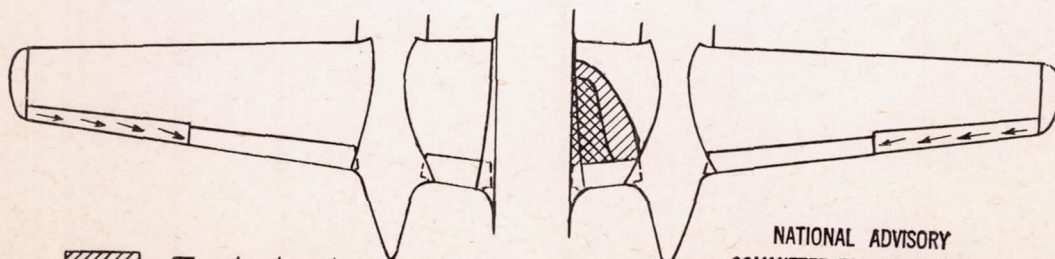




Figure 9.- Diagrams of stall progression in the gliding condition engines idling, flaps and landing gear up, cowl flaps closed, oil cooler one-half open), Douglas A-26B airplane.



*Left wing between nacelle and fuselage and right wing inboard flap not visible throughout run.*

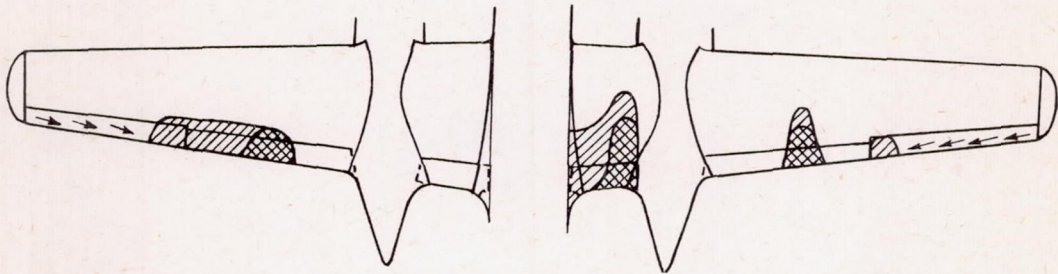
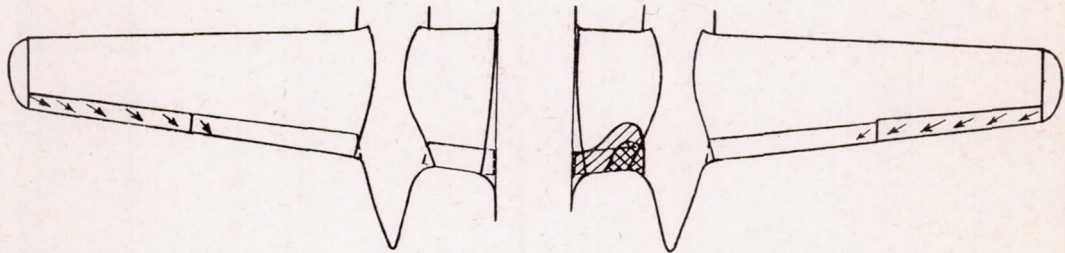


 *Turbulent*  
 *Stalled*

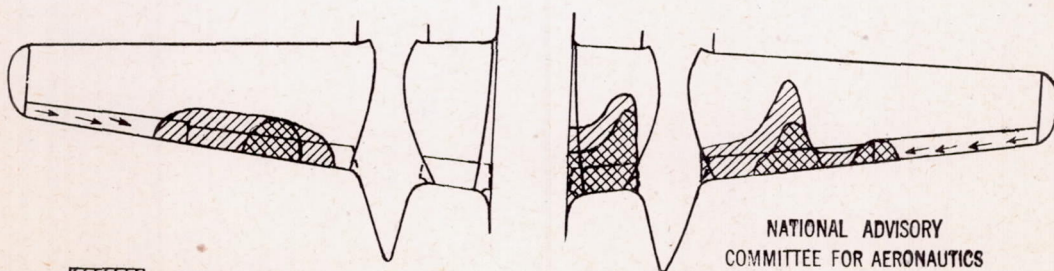
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Figure 10.- Diagrams of stall progression in the landing condition (engines idling, flaps and landing gear down, cowl flaps closed, oil cooler one-half open), Douglas A-26B airplane.





*Left wing between fuselage and nacelle not visible throughout run*



 *Turbulent*  
 *Stalled*

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Figure 11.- Diagrams of stall progression with left propeller feathered, right engine delivering normal rated power, flaps and landing gear up, oil cooler one-half open), Douglas A-26B airplane.



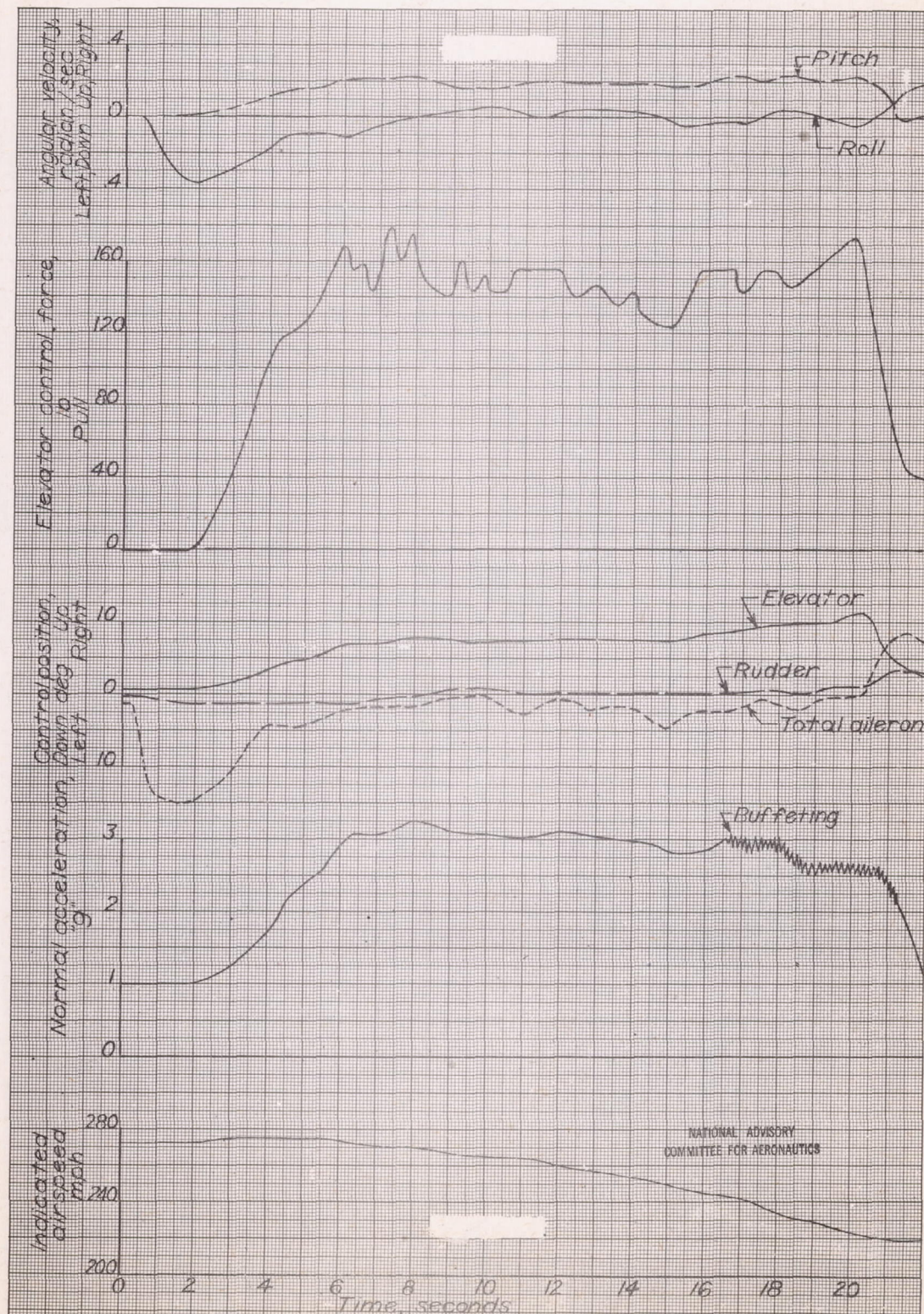


Figure 12.- Time history of a wind-up turn to the stall in the rated power, clean condition (41.5 in. Hg. at 2400 rpm, flaps up, landing gear up, cowl flaps closed, oil cooler one-half open), c.g. at 23 percent M.A.C., Douglas A-26B airplane.



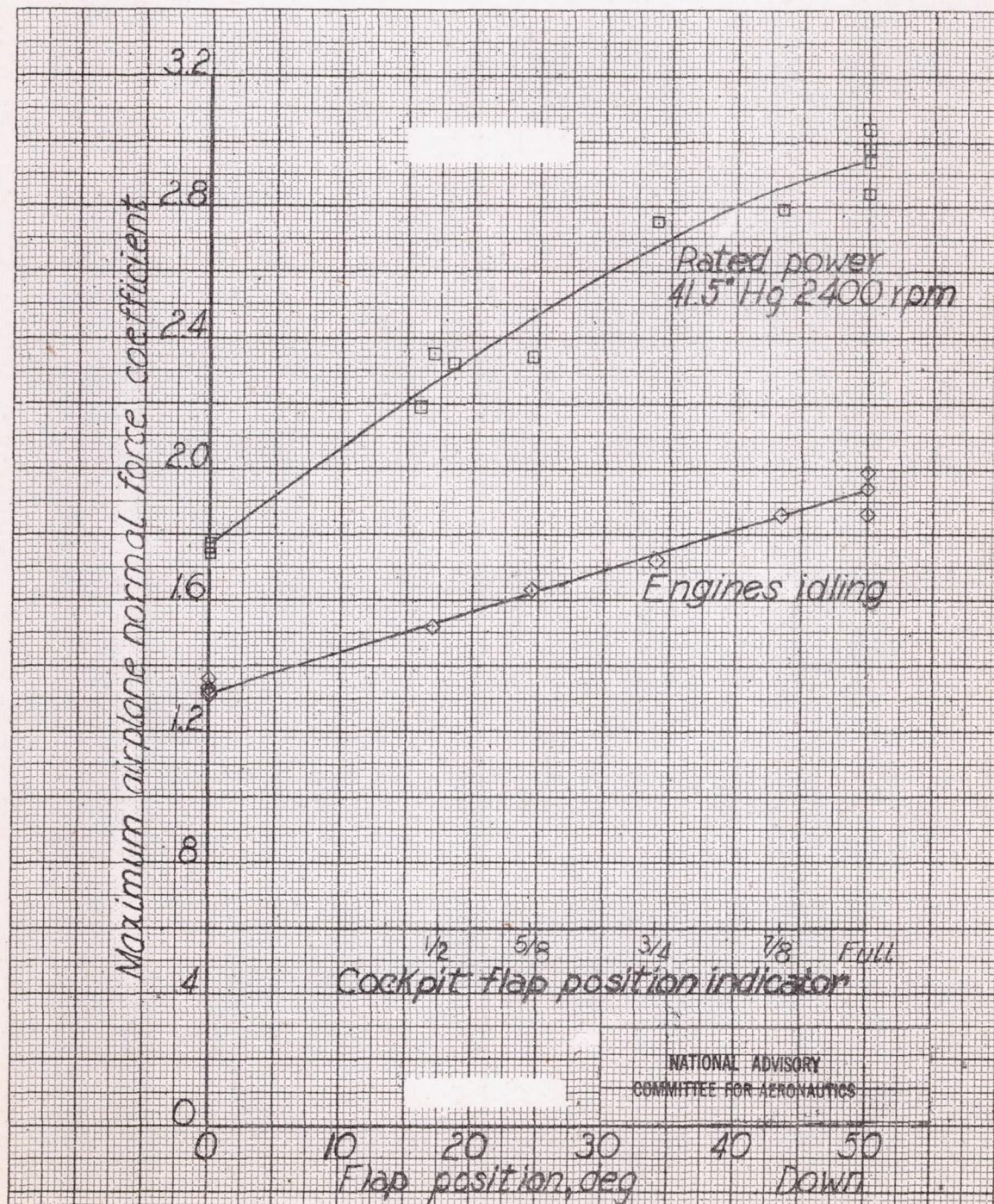


Figure 13.- Variation of maximum airplane normal force coefficient with flap position. Douglas A-26B airplane.



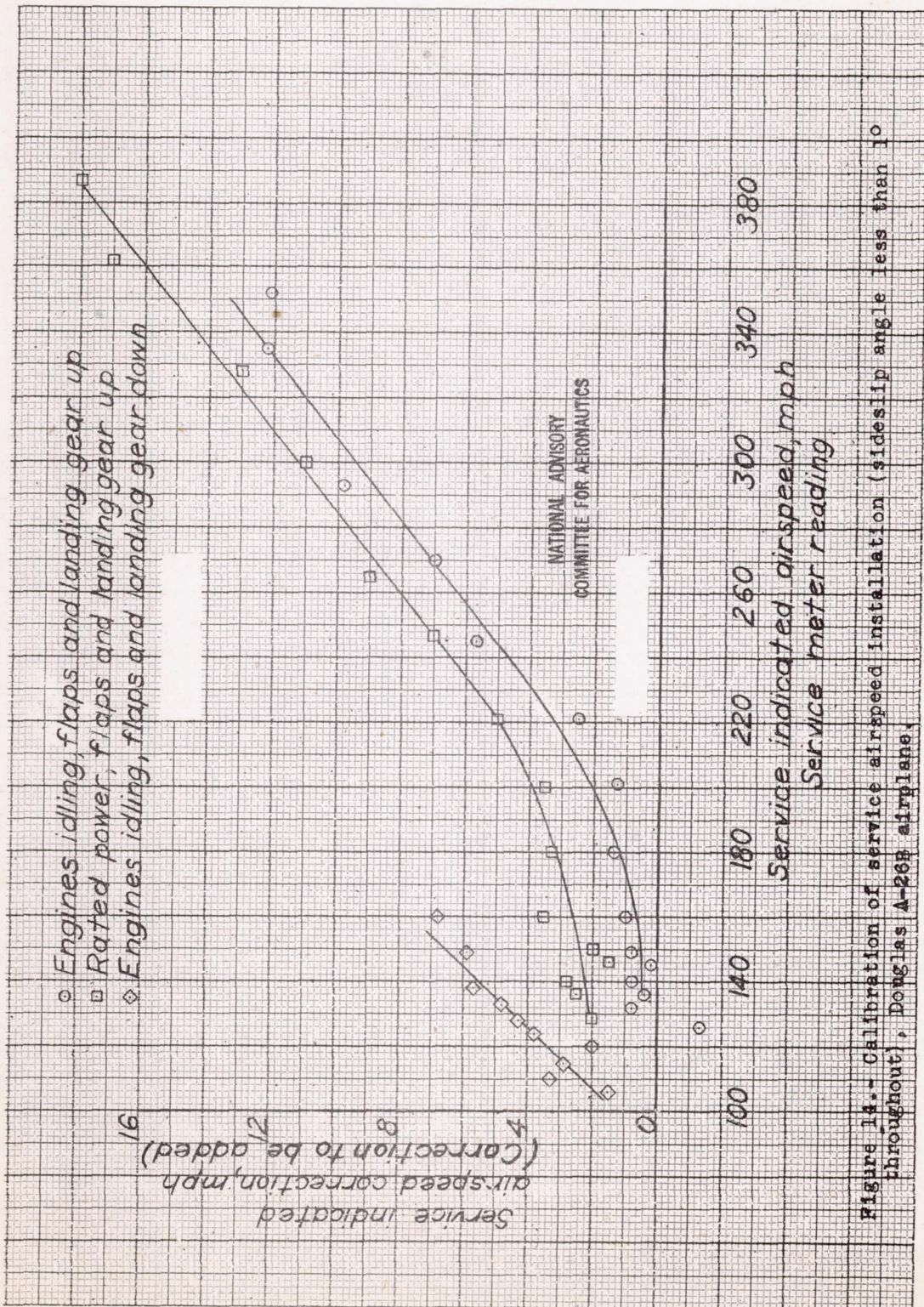


Figure 14.-- Calibration of service airspeed installation (sideslip angle less than 10 throughout), Douglas A-26B airplane.



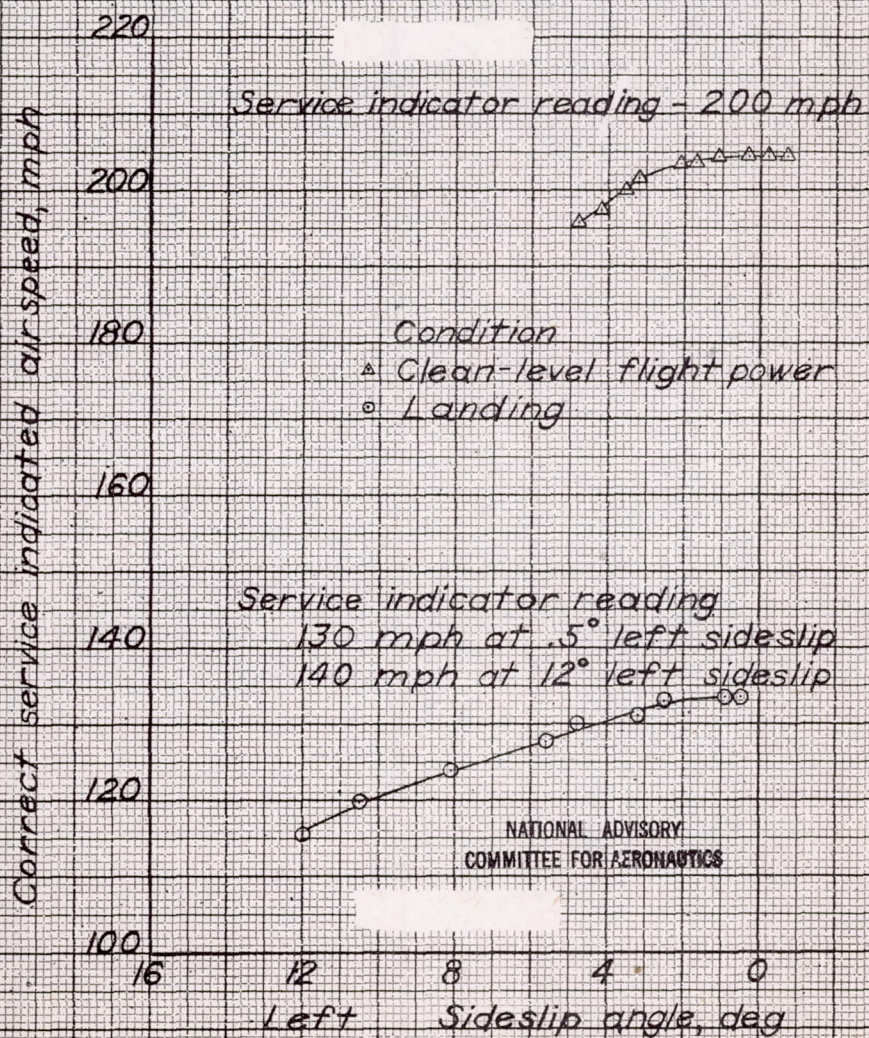


Figure 15.- Variation of correct service indicated airspeed with sideslip angle while the pilot attempted to hold a constant airspeed indicator reading in gradually increasing sideslips, Douglas A-26B airplane.